Rockfalls: predicting high-risk behaviour from beliefs

Abstract

Purpose – The purpose of this paper is to gain an understanding of the public's beliefs, attitudes and knowledge regarding rockfalls, and to see whether these variables could predict whether a person is likely to enter high-risk rockfall areas.

Design/methodology/approach – A questionnaire was developed to measure beliefs (informed by the health belief model), knowledge, and previous behaviour in relation to rockfalls. Questions were also included to measure attitudes regarding rockfall caution signs. In total, 138 members of the general public completed the questionnaire.

Findings – High-risk behaviour was more likely if the person was male and if the person had the belief that sign-posted high-risk areas were not dangerous. Further, believing that the sign-posted areas were not dangerous was more likely among people who held negative attitudes towards cautionary signs; specifically, these participants were more likely to doubt the validity of the warning signs.

Research limitations/implications – The research was exploratory in nature. Further research should be conducted with a larger sample size and a more random selection of the general population. Ways of improving measurement of the variables are discussed.

Practical implications – Efforts should be made to increase the public's perception of the validity of rockfall cautionary signs. Doing so may decrease injury and death as a result of rockfalls. Suggestions on ways to increase the validity of signage are made.

Originality/value – It is presumed that this study is the first to attempt to gain an understanding of the beliefs and attitudes that may lead a person into engaging in high-risk behaviour in relation to rockfalls.

Keywords Rocks, Landslides, Risk analysis, Knowledge management

Paper type Case study

In 1996 spectators at a primary school surf carnival, near Gracetown in Western Australia, took shelter from the rain under an overhang of a limestone cliff face. Without warning the overhang collapsed: four adults and five children were killed. Rockfalls from unstable cliff faces are very unpredictable; even when one knows that a cliff face is unstable it is very difficult to judge when the next rockfall (or landslide) will

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occur. To protect the public from such dangers, several interventions have been employed to decrease the level of risk associated with unstable cliff faces; for instance, physical removable of unstable rocks, reinforcing the cliff face with sprayed concrete, or erecting rockfall netting (Turner and Schuster, 1996). However, most of these interventions are expensive and often unacceptable to the public who object to the natural beauty of the area being destroyed. A cheaper and less offensive strategy is to discourage the public from entering the high-risk area.

One commonly used method to discourage individuals from entering high-risk rockfall areas is the use of signs cautioning of the potential dangers. The message on these signs may be conveyed in symbolic form (the use of pictures), with words, or with a combination of the two. However, the effectiveness of cautionary signs is questionable; there is anecdotal evidence which suggests that many member of the public enter high-risk areas even when there are prominent signs in the area warning of the dangers. It is possible that compliance with cautionary signs could be increased if the signs are specifically tailored to account for the general public's beliefs, attitudes, and knowledge about rockfalls. There is, however, a paucity of research that has investigated these factors. While, there have been a few studies investigating the public's knowledge (e.g., Butler and DeCano, 2005; Finlay and Fell, 1996) or acceptance (Finlay and Fell, 1996) of the landslides, we could not identify any published research that has investigated the factors associated with why individuals choose to engage in high-risk rockfall behaviour.

There are many models that identify the cognitive factors that may be associated with individuals engaging in risk increasing/decreasing behaviours. Many of these models (e.g., Paton's (2003) social-cognitive preparation model, and Ajzen's (1991) Theory of planned behaviour) deal with complex behaviours that require, for example, detailed planning, specific skills, or social negotiations. Avoiding high-risk rockfall areas, however, appears to be a relative simple behaviour: there are no specific skills required and it does not require detailed planning or lifestyle changes. The Health Belief Model (HBM: Rosenstock, 1974a, 1974b) is one model that has shown good predictability when applied to non-complex behaviours (such as dental care or health screening behaviour:, e.g. Champion, 1994; Ronis, 1992; Secginli and Nahcivan, 2006). Thus, this model seems well suited to explaining the non-complex behaviour of entering rockfall areas.

In line with the HBM, it is argued that when four conditions are satisfied an individual is likely to engage in self-protective behaviours relating to a given negative event. The individual believes that:

(1) the negative event is likely to occur (perceived susceptibility);
(2) the negative event will have a detrimental effect on their life (perceived severity);
(3) the protective behaviour will reduce their susceptibility to the negative event (perceived benefits); and
(4) there are not substantial psychological or physical barriers preventing them from adopting the protective behaviour (perceived barriers).

In the context of the present problem, the negative event is injury or death due to rockfalls and the protective behaviour is avoiding areas sign posted as dangerous because of the potential of falling rocks.

The present study aimed to measure the public's beliefs about rockfalls (perceived susceptibility and severity) and beliefs about the protective behaviour of avoiding high-risk rock fall areas (perceived benefits and barriers) and to investigate if these beliefs can predict previous high-risk behaviour. It seems likely that a person's beliefs about the benefits of avoiding areas sign posted as dangerous might be influenced by their attitudes towards the cautionary signs. Therefore, another aim was to investigate whether perceived benefits could be predicted by attitudes to caution signs. Although a few studies have been conducted concerning the general public's knowledge of landslides in general (e.g., Finlay and Fell, 1996), we are not aware of any studies that have investigated the public's knowledge of rockfalls. Thus, the final aims were to measures the public's knowledge concerning rockfalls and to investigate whether this knowledge would predict previous high-risk behaviour.

Method

The research was undertaken in Barwon Heads: a small coastal town in Victoria, Australia, located approximately 100 km south-west of Melbourne. This popular seaside resort is located at the mouth of the Barwon River on the Victorian Coast and attracts both local residents and tourists (mainly of Australian nationality), but is adjacent to a prominent cliff face from which rockfalls occur on a relatively regular basis. Despite the fact that there are many signs alerting beach users to the dangers of approaching the cliff, the park rangers report that they often observe individuals engaging in high-risk behaviour by venturing too close to the face of the cliff.

Questionnaires were placed in various locations throughout the town (e.g., main office of the local caravan park, cafes, hairdressers, etc.) with posters encouraging participants to take a copy and return it in the reply paid envelope. Advertisements were placed in local papers alerting the public to the questionnaire and also listed a website where the questionnaire could be completed online. As an incentive, individuals who returned the questionnaire had the chance of entering a prize draw to win a $100 gift voucher.

Measures

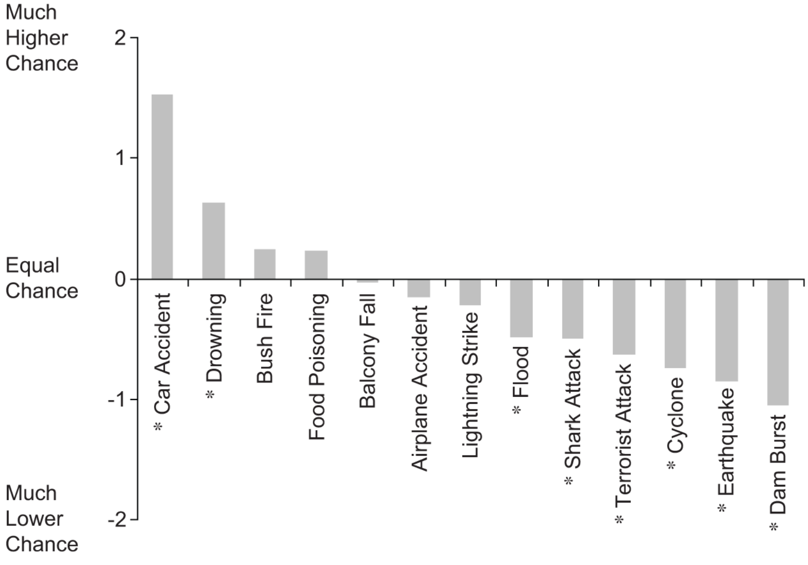
HBM measures. Three questions were used to measure perceived susceptibility, perceived severity and perceived barriers. These questions (and the accompanying scales) are presented in Table I. Perceived susceptibility was also gauged by presenting participants with a list of thirteen negative events (see Figure 1) and asking them to compare the chance of being killed in a rockfall to the chance of being killed by each event in the list. Participants responded to each event on a 5-point scale ($2 =$ much higher chance than falling rocks; $0 =$ same chance as falling rocks; $-2 =$ much lower chance than falling rocks). This data was converted into a single variable by subtracting the number of events with a lower risk from the number with a higher risk. To identify the perceived barriers to the protective behaviour, participants who had indicated that they had previously entered a high-risk area were asked to list the reason(s) they had done so.

Attitude towards caution signs was gauged by participants indicating how much they agreed or disagreed with seven statements about warning signs. Table II presents these statements (and the response scale).

	Mean	SD	B	SE B	OR
Perceived susceptibility					
In your lifetime, what do you think is your chance of being injured by a rock falling from a cliff face?[a]	2.18	1.43	−0.317	0.16	0.73*
Number of events with lower chance of fatality than rockfalls minus number of events with a higher chance[b]	0.96	5.82	0.03	0.04	0.98
Perceived severity					
On average how serious do you think the injuries are from rocks falling from cliff faces in areas that have been sign-posted as "dangerous"?[c]	5.44	1.47	−0.026	0.16	0.77*
Perceived benefits					
If a person enters an area that has been sign-posted as "dangerous" due to falling rocks from a cliff face, what do you think is the chance that they could be injured?[a]	3.90	1.66	0.56	0.16	1.6*

Notes: $^{*}p < 0.05$; [a]Rated on a seven point scale: 1 = not at all likely, 4 = equally as likely as not likely, 7 = extremely likely; [b]Positive numbers indicate that rockfalls were perceived as being more likely than other events, while negative numbers indicate that rockfalls were perceived as being less likely than other events. Scale ranged from −13 to +13; [c]Rated on a seven-point scale: 1 = not at all serious; 7 = extremely serious

Table I. Summary of the logistic regression used to predict high-risk behaviour with the health belief model variables



Note: One-sample t-tests were used to compare each event with zero (equal chance): * $p < 0.001$

Figure 1. Participants' perception of the chance of fatalities caused by each event compared with the chance of fatalities caused by rockfalls

Table II.
The percentage of participants who agreed and disagreed with the seven attitudinal statements regarding warning signs, the Mean (SD) response to the attitudinal statements and summary of the standard multiple regression predicting perceived benefits from the attitudinal variables

Attitudinal variables	% Agreed[a]	% Disagreed[a]	Mean	SD	B	SE B	B
1. In general I do not notice warning signs	6.6	86.1	1.67	0.95	−0.02	0.15	−0.01
2. Some warning signs regarding falling rocks are difficult to understand	17.4	69.6	3.91	1.27	−0.08	0.11	−0.06
3. Warning signs are put up when rocks are falling on a regular basis	33.3	35.5	3.00	1.28	−0.30	0.11	−0.23*
4. They put up warning signs even if there is only a very small chance that you could be injured by falling rocks	68.6	16.8	2.18	1.18	0.32	0.12	0.23*
5. Authorities put up warning signs about falling rocks mainly to avoid being sued if someone gets injured	39.9	32.6	2.84	1.36	−0.04	0.11	−0.04
6. Warning signs advise you of the hazards in the area but you still have the right to choose whether or not you can go into the area	65.7	19.7	2.32	1.27	0.18	0.13	0.13
7. You get into trouble from the authorities if you enter an area that has been posted with warning signs	35.3	38.2	3.13	1.35	−0.23	0.12	−0.19*

Notes: $R^2 = 0.22$ ($p < 0.001$); $^*p < 0.05$; [a]Proportions relating to participants that neither agree nor disagree are not included; [b]Responses were made on a five-point scale (1 = strongly agree, 5 = strongly disagree)

To measure knowledge concerning rockfalls, participants were given a list of events (see Table III) and were asked to indicate which events they thought increased the chance of falling rocks. Participants were also asked to indicate how large a falling rock would have to be to, respectively, injure and fatally injure somebody. Participants responded to these questions by choosing one of the following options: approximately the size of a marble (1 cm), golf ball (4 cm), cricket ball (7 cm), basket ball (24 cm), large beach ball (60 cm), large washing machine (1-1.5 m), small hatchback car (2-3 m). Participants were also asked to indicate a safe distance from a cliff face and the distance from the cliff face most rocks fall. Participants responded to these questions on the following scale: 1 m, 5 m, 10 m, 15 m, 25 m, or 50 m.

Previous high-risk behaviour was measured by asking participants to indicate whether they had previous entered an area that had been sign posted as high-risk due to falling rocks. Participants responded to this question by indicating either yes or no.

Data analysis

Data were analysed using Statistical Package for Social Science (SPSS) version 14. Descriptive statistics were used to examine belief, attitude and knowledge variables. Two logistic regression analyses were used to predict risk behaviour. One was used to predict risk behaviour with four HBM variables (perceived severity, perceived benefit and the two perceived susceptibility variables; note that perceived barriers was not used in this analysis because it was only measured among high-risk participants), the other was used to predict risk behaviour with the knowledge variables (knowledge of risk factors; size of rocks large enough to, respectively, injure and kill; safe distance from cliff face; and distance that falling rocks travel). In both analyses, gender and age were entered at Step 1 and the respective independent variables were entered at Step 2. Step 1 was significant ($\chi^2(2, n = 130) = 12.50, p = 0.002$, Cox and Snell $R^2 = 0.09$) in both analyses. Gender, however, was the only significant predictor ($exp(b) = 3.62$, $\chi^2_{\text{Wald}}(\text{df} = 1) = 11.70, p = 0.001$); the results showed that males were approximately three and a half times more likely to engage in the high-risk behaviour than females. The contribution of the variables entered at Step 2 was assessed after removing the variability accounted for by gender and age. Standard multiple regression was used to predict perceived benefit with the attitude variables. Prior to conducting the regression analyses, the data was screened for violations of the regression assumptions – no violations were identified.

	Event	% Indicating high risk
High-risk events	Heavy downpour of rain	85.4
	Prolonged rain	89.1
	Earthquakes	86.8
	People climbing over rocks	80.3
Low-risk events	Light rain	16.8
	Traffic	33.3
	Extremely dry weather	66.4
	Nesting birds	22.6

Table III. The percentage of participants who indicated that the high- and low-risk events were likely to increase the chance of falling rocks

Results

Sample

Questionnaires were returned by 138 participants. Slightly more females (54.3 per cent) completed the questionnaire than males (45.7 per cent). The average age of the participants was 48.8 years (SD = 13.9). Over half the participants (55.8 per cent) indicated that they had gained a tertiary education, and a further 29 per cent indicated that they had received training/education post secondary school. Fifty eight percentage of participants indicated that they considered themselves locals of the Barwon Heads region. The majority of the participants (84.8 per cent) indicated that they had visited the beach area at the Barwon Bluff. Over half of the participants (57 per cent) indicated that they had previously entered a high-risk rockfall area.

HBM variables

Table I presents the mean responses for perceived susceptibility, severity and benefits. As can be seen in the table, in regard to perceived susceptibility, participants saw their lifetime chance of being injured in a rockfall at the low risk end of the scale, but when the chance of a rockfall was compared to the 13 other events, on average, participants scored in the middle of the scale. Further analysis of this second variable revealed that participants estimated the mortality rates associated with rockfalls to be higher than six of the events, equivalent to five, and less than two of the events; this information is graphically represented in Figure 1. Statistics suggest that at least two of these events that were rated equivalent to rockfalls – aeroplane accident and falls from a balcony – should have been rated as higher (Higson, 1989; NSC, 2003)

As can be seen in Table I, on average, participants gave high ratings for perceived severity. In regard to perceived benefits, participants rated the likelihood of an injury in a high-risk area as slightly lower than a 50 per cent chance (furthermore, this was rated a significantly more likely than the participants own likelihood of being injured in a rockfall: $t\,(136) = 11.85, p < 0.001$), thus on average participants perceived it to be beneficial to engage in the protective behaviour of avoiding the high-risk area. To gauge perceived barriers, high-risk participants were asked to list the reasons for entering a high-risk area. The most commonly cited reason were: to explore the area (51.9 per cent), it was the quickest route to where they were going (36.4 per cent), or they believe that the area was not very dangerous (33.8 per cent).

Table I also presents a summary of the logistic regression used to predict high-risk behaviour when the HBM variables were entered at Step 2. Compared to when only age and gender were entered, the prediction of previous high-risk behaviour increased significantly with the entry of the HBM variables (χ^2 (df = 4) = 16.09, $p = 0.003$; Cox and Snell $R^2 = 0.20$). However, only two of these four variables contributed significantly: one of the perceived susceptibility measures (lifetime chance) and perceived benefits. People who indicated that their lifetime chance of injury was higher and people who rated entering a high-risk area was associated a lower chance of injury were more likely to engage in high-risk behaviour.

Attitudes about warning signs

Table II presents that number of participants that agreed and disagreed with the statements regarding warning signs. Also presented in the table are the mean (and standard deviations) for each statement. As can be seen the majority of participants indicated that they generally noticed warning signs, they found rockfall warning signs easy to understand, believed that warning signs were erected even if there was only a small chance of injury from rockfalls, and believed that the public had the right to chose whether or not to enter a high-risk area. The participants were much more divided on the remaining items.

Table II also summarises the multiple regression used to predict perceived benefits from the seven attitudinal variables. The attitudes variables significantly predict perceived benefits: $F(7, 126) = 4.95$, $p < 0.001$. However, only statements three, four, and seven were significant predictors. The more likely participants were to disagree with statements three and seven, and agree with statement four, the more likely the participants were to perceive low danger in rockfall areas.

Knowledge

Table III presents the high and low risk events and the percentage of participants who indicated that the event was likely to increase the chance of falling rocks. As can be seen in the table, the majority of participants (80-90 per cent) could identify the factors that increased the chance of falling rocks, but there was also tendency for participants to classify low risk events as high-risk (e.g., extremely dry weather). An overall risk-factor knowledge score was calculated based on the number of factors correctly classified minus those incorrectly classified (range: -8 to 8). The average score was in the upper end of the scale, indicating that in general the sample had good knowledge ($M = 4.08$, $SD = 2.55$).

The majority of participants indicated that a rock the size of either a marble (32.8 per cent), golf ball (38.1 per cent), or cricket ball (23.1 per cent) was likely to cause an injury in a rockfall. Rocks the size of a golf ball (25.9 per cent), cricket ball (34.1 per cent), or basketball (23.7 per cent) were the most frequently cited responses when participants were asked to indicate the size that could fatally injure somebody.

Approximately two thirds of participants (67.4 per cent) indicated that rocks usually landed within one or five meters from a cliff face, and a further 20.5 per cent indicated within 10 meters. In regard to a safe distance from the cliff face, the responses were much more mixed: 11.9 per cent indicated one or five meters, 25.9 per cent indicated 10 meters, 17.8 per cent indicated 15 meters, 25.2 per cent indicated 20 meters and 19.3 per cent indicated 50 meters.

After controlling for gender and age, it was found that the above knowledge variables did not significantly predict previous high-risk behaviour: $\chi^2(\mathrm{df} = 5, n = 130) = 2.57$, $p > 0.05$.

Discussion

The aim of the study was to gain an understanding of public's beliefs, attitudes and knowledge regarding rockfalls, and to see whether these variables could predict previous high-risk behaviour (that is whether the participants had previously entered an area that had been marked as dangerous due to falling rocks). According to the HBM, the public are likely to avoid high-risk rockfall areas if they perceive the consequences of a rockfall as serious and the likelihood of injury from rockfall as high. We found that the public did indeed perceive rockfalls as serious event. Even though the participants perceived their own chance of injury in a rockfall as low, they did not seem to be underestimating the chance of fatalities associated with rockfalls; when participants were asked to compare the chance of a fatality from a rockfall to the chance associated with other events, they overestimated the likelihood of rockfall fatalities.

Also in line with the HBM, the public are unlikely to enter a high-risk rockfall areas if they perceived that avoiding the area will reduce their risk (perceived benefit) and there are no substantial psychological or physical barriers preventing them from adopting the protective behaviour (perceived barriers). It was found that participants saw it as beneficial to avoid the high-risk areas: indeed they perceived that there was almost a 50 per cent chance of being injured upon entering a high-risk area. The two most commonly cited barriers among high-risk individuals were that obeying the signs prevented them from exploring the area and would have increased the time required to travel to their destination.

In combination the perceived severity (two measures), perceived susceptibility, and perceived benefit significantly predicted previous high-risk behaviour. However, only perceived benefit and only one of the perceived susceptibility variables (lifetime chance) contributed significantly. Consistent with the HBM, high-risk individuals perceived lower benefits from avoiding the high-risk area; that is, high-risk individuals saw the risk associated with entering a high-risk area as lower than did low-risk individuals. However, inconsistent with the model, high-risk individual were more likely to perceive their susceptibility as higher. This latter finding suggests that, rather than behaviour being influenced by beliefs, as the model suggests, behaviour may have been used by the participants to inform their beliefs. Thus, the only HBM variable that was useful in predicting high-risk behaviour was perceived benefits.

The data suggest that many people doubt the validity of warning signs. Approximately two thirds of the participants thought that warning signs were erected even when there was only a small chance of injury, about one third thought that warning signs were erected even if rocks were not falling on a regular basis, and about 40 per cent thought that the main reason authorities put up warning signs was to avoid being sued. Furthermore, a third of the people who had previously entered a high-risk area indicated that they had done so because they thought the area was not very dangerous. As predicted, one's attitude regarding warning signs predicted the perceived benefits of obeying the warning signs. Participants perceived the likelihood of injury in a high rockfall area as more likely if they thought that warning signs were erected when rocks were falling on a regular basis, warning signs indicated there was more than a small chance that one could be injured by falling rocks, and that one could get into trouble from authorities if they disobeyed the warning signs.

The participants' knowledge concerning rockfalls was generally good. Most participants could correctly identify the factors that increased the chance of rockfalls. (However, there was a tendency for many people to also indicate that low probability events were also likely to cause rockfalls.) Most participants indicated rocks the size of a cricket ball or smaller were large enough to injure somebody, and about two thirds thought that similar sized rocks would also be large enough to kill somebody. The majority of participants indicated that the rocks would land within 10 m from the cliff face and most indicated that at least 10 m from the cliff face would be a safe distance to avoid injury. However, it is worth noting that at least one in ten people indicated that a safe distance was five meters or less from the cliff face. Obviously the distance that most rocks would land from a cliff face and, therefore, the safe distance from a cliff face varies depending on the location. However, distances of five metres or less from the base of the cliff face contain the majority of fallen material at many sites and, by inference, would be considered to be of a higher risk. Thus it is possible that the public might benefit from being informed of the safe distances from cliff faces. None of the knowledge variables measured, however, predict previous high-risk behaviour. This finding suggests that providing the public with information aimed at increasing their knowledge of rockfalls is not sufficient to change high risk behaviour.

Taken together the above findings suggest that the only variable that usefully predicts high-risk behaviour is a person's belief concerning how likely an injury is if one enters an area sign posted as dangerous. People who believe that sign posted areas are not in fact very dangerous are much more likely to enter than a person who believes that these areas are dangerous. Furthermore, the data suggests that people who do not see these areas as very dangerous are also more likely to doubt the validity of warning signs about rockfalls. This suggests that the best way to deter people from engaging in high-risk rockfall behaviour is to increasing the public's perception of the validity of warning signs. Given the findings concerning the other variables, it would appear that interventions designed to increase perceived threat (i.e. severity and susceptibility to rockfalls) or knowledge about rockfalls in general would not be effective in reducing high-risk behaviour.

How then does one increase the perceived validity of cautionary signs? It maybe that rather than changing the publics perception about rockfalls in general, attempts could be made to change the way the public perceive rockfalls in specific locations. That is, rather than changing knowledge or perception of risk about the dangers of rockfalls in Australia in general, the public could be given information relating to specific rockfalls sites. Indeed it is possible that cautionary signs that include information about the frequency and/or severity of rockfalls in a particular area may serve to bolsters the validity of the cautionary signs. Another method of increasing the perceived validity of the signage may be to use a grading system on the signs. For instance, an area with a low probability of rockfalls is given a lower grading than an area with a higher probability. In this way, the low risk individual will be given enough information to avoid the area, and the high-risk individual is given enough information to make an informed choice about engaging in the behaviour (high-risk individuals will know what the level of risk is, rather than simply assuming that the risk is low). Such a system might reinforce the validity of the signage because it may indicate to the public that the signs are erected after the area has been thoroughly assessed in terms of the potential danger.

The present study was exploratory in nature; as such there are several ways this study could be improved. The participants in the present sample were recruited from only one area and the sample was self-selecting; thus, future research could focus on obtaining a more representative sample of the general public. There were also issues with the measurement of some of the variables. Perceived barriers were only measured among high-risk users and therefore could not be included to predict behaviour. The two barriers identified in this study (restriction of exploration and increased travel time) could be incorporated into future studies to see if these increase the predictability of high-risk behaviour. Further, it is possibly that the predictiveness of the HBM was affected by the way that previous risk behaviour was measured. The question in the present study asked whether or not the participant had previously engaged in the high-risk behaviour without specifying a time range. It is possible that an individual may have engaged in the high-risk behaviour well in their distant past when they held different beliefs than they do today. Future research might find that if a current time frame is specified (for example, the previous 12 months), the predictability of the model might increase. Also, the measurement of participants' knowledge of risk factors could also been improved. Given that there was a tendency for participants to select factors as risk increasing, participants could be asked to rank the factors from most likely to cause rockfalls to least likely.

In the present study, gender was also found to significantly predict high-risk behaviour; males were more likely to have previously entered a high-risk area than females. This finding is not surprising given that previous research shows that males are more likely to engage in risky behaviours than females (Byrnes *et al.*, 1999). Further, previous research has found that males are particularly likely to engage in high-risk behaviour when they are in the company of other males (Ronay and Do-Yeong, 2006). This suggests that social factors may be influential in whether people engage in high-risk behaviour; indeed it seems possible that some people enter the high-risk areas because of peer pressure or assurances from others that the area is safe. Future research may, therefore, benefit from measuring social factors.

In summary, it seems that if cautionary signs are used to discourage people from entering high-risk areas efforts should be made to increase the perceived validity of such signs. The data suggests that efforts to educate the public about rockfalls in general maybe insufficient when trying to changing the behaviours of high risk individuals. However, educating the public about specific rockfall areas might increase the perceived validity of warning signs, which in turn may influence the perceived benefits of adhering to the warning signs and that in turn may lead to low risk behaviour.

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Corresponding author
Helen Aucote can be contacted at: helen.aucote@acu.edu.au